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The Coordination Stemmed likely from the Co-Variety of Soil Water and Supplement Accessibility along the Saltiness Inclination

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Abstract

Background: Independence among leaf economics, leaf hydraulics and leaf size confers plants great capability in adapting to heterogeneous environments. However, it remains unclear whether the independence of the leaf traits revealed across species still holds within species, especially under stressed conditions. Here, a suite of traits in these dimensions were measured in leaves and roots of a typical mangrove species, which grows in habitats with a similar sunny and hot environment but different soil salinity in southern China.

Keywords: Soil water • Water • Supplement

Introduction

Compared with low soil salinity, under high soil salinity had lower photosynthetic capacity, as indicated directly by a lower leaf nitrogen concentration and higher water use efficiency, and indirectly by a higher investment in defense function and thinner palisade tissue; had lower water transport capacity, as evidenced by thinner leaf minor veins and thinner root vessels; and also had much smaller single leaf area [1]. Leaf economics, hydraulics and leaf size of the mangrove species appear to be coordinated as one trait dimension, which likely stemmed from co-variation of soil water and nutrient availability along the salinity gradient [2].

Description

The intraspecific leaf trait relationship under a stressful environment is insightful for our understanding of plant adaption to the multifarious environments. Leaf photosynthesis, a fascinating process in transforming atmospheric CO2 into carbohydrate, is fundamental for plant growth and ecosystem functioning [3]. For terrestrial plants, there is a conspicuous trade off regarding CO2 assimilation, i.e., the leaf economics spectrum (LES), depicting that leaves with a high photosynthetic rate usually have a short lifespan, and vice versa. To maintain photosynthesis, leaves should be supplied with sufficient water. The efficiency of the water supply system in leaves is determined by leaf minor veins which act as 'the super highway' for delivering water to photosynthetic tissues. Leaf minor vein traits, such as the minor vein diameter and density (minor vein length per unit leaf area), are closely related to leaf hydraulic conductance and are commonly used as leaf hydraulic traits. Although LES and leaf hydraulics are sparsely reported to be coupled, they are increasingly recognized as independent trait dimensions worldwide (see the classical reviewer paper and references therein), as such forming a multidimensional trait space in leaves [4]. The multi-dimension relative to the single LES dimension is commonly recognized to confer plants more ecological strategies (i.e., more trait combinations) for adaption to heterogeneous environments.

The decoupling between LES and leaf hydraulics could be related to light and soil water availability which vary independently under natural conditions and differently affect the two trait dimensions. For example, all else being equal, sites with high light intensity usually have high temperature, consequently causing greater water loss through evaporation and low soil moisture. Soil moisture at the high light sites could be high in cases of sufficient water sources such as rivers, groundwater or abundant precipitation. This will cause out-of-sync variations between light and soil water availability and hence multifarious environmental niches. The decoupled light and water availability can affect leaf mesophyll and leaf minor veins separately, thereby driving the formation of decoupled LES and leaf hydraulics.

Leaf size is another important trait dimension reflecting plant adaptation to environmental temperature through an adjustment of the leaf-level energy balance. For example, large leaves have a thick boundary layer that slows sensible heat loss from the leaf surface. This causes large leaves a great risk of lethal temperature damage in hot and dry environment with limited transpirational cooling [5]. Mounting evidence shows the independence of leaf size from leaf hydraulics represented by minor vein density. Such decoupled trait dimensions could also be related to independent variation of light and soil water availability. For example, species with similar leaf vein density under moist conditions could have different light and heat conditions, which allows plants to produce different leaf size to balance leaf-level heat exchange. To better understand how plants adapt to the multifarious environmental niches, it is necessary to concomitantly take into account leaf economics, hydraulics and size dimensions. However, most studies concentrate on only one (e.g., leaf size, hydraulics or two of the trait dimensions (e.g., hydraulics and economics, economics and size. Most importantly, our knowledge of the trait relationships comes mainly from interspecific comparisons under unstressed conditions. It remains unclear how the above three trait dimensions vary in a coordinated or decoupled way at the intraspecific level, e.g., comparing a species along a stress gradient.

Mangrove trees usually grow in intertidal zones in the tropics and subtropics suffering from salt stress. One of the conspicuous adverse effects by the salt stress is that it can cause difficulty in water absorption by plant roots, i.e., physiological drought, given the low osmotic potential of the soil solution around the roots. A salinity gradient is frequently observed in mangrove habitats, with lower salinity in river estuaries and higher salinity along open coasts. Here, we selected a typical mangrove species, growing at two habitats with similar light conditions but different soil salinities. We hypothesized that leaf economics, hydraulics and size are coupled rather than decoupled along the salinity gradient. This is because salinity-induced physiological drought usually varies coordinately with the soil nutrient content in mangrove habitats.

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For example, river estuaries generally have lower salinity (lower physiological drought for plants) and higher soil nutrients whereas open coasts have higher salinity (higher physiological drought) and lower soil nutrients. Under similar sunny and hot conditions, coupled soil water and nutrients could drive leaf economics, hydraulics and size to vary in a coordinated rather than a decoupled manner.

The study was conducted in the Dongzhai Harbor National Natural Reserve for the mangrove ecosystem, Hainan Island China (19°51′N-20°01′N, 110°30′E–110°37′E). This location has the richest mangrove species in China. For detailed information of the mangrove communities in this area, please can refer. The area has a tropical monsoon climate with mean annual precipitation of 1676 mm and mean annual air temperature of 23.5°C. Almost 80 percent of the annual precipitation occurs from May to October. Here, we selected a common mangrove species, which naturally grows in mono-specific stands with ages older than 60 years. A typical species in usually growing in coast beach as a shrub or a small tree. well-adapted to the sunny, hot and high salinity coast environment by bearing leaves with thick cuticle, high tannin content and sunken stomata.

In the growing season in May 2015, we collected the roots and leaves of C at two sites with different soil salinities and nutrient contents. One site was located near the seashore of the outer part of the bay with high salinity and a low soil nutrient content at this site grew as tall as 1-1.5 m. The other site was in the Yanfeng River estuary, located in the inner part of the bay where C. This site was characterized with lower salinity and a higher soil nutrient content relative to the aforementioned site.

Discussion

At each site, we randomly selected 5 mature *C. tagal* trees. For each tree, 15–20 intact leaves without herbivory damage were collected; 3-5 leaves were fixed in solution (90 ml 70% ethanol, 5 ml 100% glacial acetic acid and 5 ml 37% methanol) for leaf anatomy, and the remaining leaves were used to determined leaf morphology, nutrients, defensive chemicals and minor vein diameter and density. To test the covariation of the hydraulics between leaves and roots, we also collected the first-order roots along with the leaf samples and immediately placed the roots in the fixation solution for subsequent root anatomy measurements.

Conflict of Interest

The authors declare that there is no conflict of interest associated with this manuscript.

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